

WHAT IS CLAIMED IS:

1. An apparatus comprising:

a sender including

a first controller configured to identify a forward item including a transmit
5 portion and a retain portion;

a first tag generator configured to generate a tag and associate the tag with the
retain portion;

a first transmitter configured to send the transmit portion, but not the tag, to a
target;

10 wherein the target includes

a first receiver configured to receive the transmit portion;

a second controller configured to identify a return portion corresponding to
the transmit portion;

a second tag generator configured to independently generate the tag and
15 associate the tag with the return portion;

a second transmitter configured to send the return portion and the tag to the
sender;

wherein the sender includes;

a second receiver configured to receive the return portion and the tag; and

20 wherein the first controller is configured to identify the retain portion using the tag
and associate the return portion with the retain portion to create a reverse item.

2. The apparatus of claim 1, further comprising:

means for initializing the first and second tag generators to generate the same tags in
25 the same order.

3. The apparatus of claim 2, wherein each of the first and second tag generators
includes a buffer and means for initializing comprises:

means for loading each buffer with a set of tags such that both buffers contain the
30 same tags in the same order and no tag in the set is the same as any other tag in the set.

4. The apparatus of claim 3, wherein the first tag generator is configured to remove the tag from the buffer.

5. The apparatus of claim 4, wherein the first controller is configured to return the tag to the first tag generator after associating the return portion with the retain portion.

6. The apparatus of claim 5, wherein the second controller is configured to return the second tag to the second tag generator after sending the return portion.

7. The apparatus of claim 1, wherein the sender and target are different layers of a multi-layer switch coupling a processor to a memory, the forward item includes a memory transaction, and the reverse item includes a result of the memory transaction.

8. The apparatus of claim 7, wherein the processor is a graphics processor.

9. The apparatus of claim 1, wherein the sender is a processor and the target is a layer in a multiple-layer switch having a plurality of layers.

10. The apparatus of claim 9, wherein the processor is a graphics processor.

11. The apparatus of claim 2, wherein each of the first and second tag generators includes a counter and means for initializing comprises:
means for setting both counters to the same value.

12. The apparatus of claim 11, wherein means for associating a tag comprises:
means for incrementing the counter; and
means for associating the value output by the counter with the tag.

13. The apparatus of claim 11, wherein the counters are incremented continuously according to a clock signal and each tag generator is configured to associate the value output by the counter with the tag.

14. An apparatus comprising:

a controller configured to identify a forward item including a transmit portion and a retain portion;

5 a tag generator configured to associate a tag with the retain portion;

a transmitter configured to send the transmit portion, but not the tag, to a target that identifies a return portion corresponding to the transmit portion, independently generates the tag, and associates the tag with the return portion; and

a receiver configured to receive the return portion and the tag from the target;

10 wherein the controller is further configured to identify the retain portion using the tag and associate the return portion with the retain portion to create a reverse item.

15 15. An apparatus comprising:

a receiver configured to receive a transmit portion of an item from a sender that associates a tag with a retain portion of the item and sends the transmit portion, but not the tag;

a controller configured to identify a return portion corresponding to the transmit portion;

20 a tag generator configured to independently generate the tag and associate the tag with the return portion;

a transmitter configured to send the return portion and the tag to the sender, wherein the sender identifies the retain portion using the tag and associates the return portion with the retain portion to create a reverse item.

25 16. A switch comprising:

a plurality of input elements, each coupled to an internal switch bus;

a plurality of output elements, each coupled to the internal switch bus, and each coupled to a different destination external to the switch;

wherein each input element is configured to

30 receive an item including an address portion specifying one of the output elements, and

send the item and the internal switch address of the input element to the output element specified by the address portion; and

wherein each output element is configured to

receive a first item including an address portion specifying the output element,

remove from the first item the portion of the address specifying the output element,

generate a tag uniquely identifying the first item to the output element,

associate the tag and the internal switch address of the input element,

send the first item, but not the tag or the portion of the address specifying the output element, to the destination coupled to the output element, wherein the destination independently generates the tag and identifies a second item corresponding to the first item,

receive the second item and the tag from the destination,

identify the internal switch address of the input element using the tag, and

send the second item to the input element using the internal switch address of the input element.

17. An apparatus comprising:

means for receiving, at a switch, an item sent from a source, the item associated with a first tag identifying the item uniquely to the source;

means for associating a second tag with the first tag, the second tag identifying the item uniquely to the switch; and

means for sending the item, but not the second tag, to a destination.

18. The apparatus of claim 17, further comprising:

means for receiving a second item and the second tag from the destination;

means for identifying the first tag using the second tag; and

means for sending the second item and the first tag to the source.

19. The apparatus of claim 17, wherein the destination is a second switch, further comprising, at the second switch:

means for independently generating the second tag;

means for associating a third tag with the second tag, the third tag identifying the item uniquely to the second switch; and

means for sending the item, but not the third tag, to a second destination.

5 20. The apparatus of claim 19, further comprising, at the second switch:
means for receiving a second item and the third tag from the second destination;
means for identifying the second tag using the third tag; and
means for sending the second item and the second tag to the switch.

10 21. The apparatus of claim 20, further comprising, at the switch:
means for receiving the second item and the second tag from the second switch;
means for identifying the first tag using the second tag; and
means for sending the second item and the first tag to the source.

15 22. A method comprising:
at a sender,
 identifying a forward item including a transmit portion and a retain portion;
 generating a tag;
 associating the tag with the retain portion;
20 sending the transmit portion, but not the tag, to a target;
at the target,
 receiving the transmit portion;
 identifying a return portion corresponding to the transmit portion;
 independently generating the tag;
25 associating the tag with the return portion;
 sending the return portion and the tag to the sender;
at the sender,
 receiving the return portion and the tag;
 identifying the retain portion using the tag; and
30 associating the return portion with the retain portion to create a reverse item.

23. The method of claim 22, wherein the tag is independently generated by a first tag generator at the sender and by a second tag generator at the target, further comprising:
initializing the first and second tag generators to generate the same tags in the same order.

24. The method of claim 23, wherein each of the first and second tag generators is a buffer and initializing comprises:

loading each buffer with a set of tags such that both buffers contain the same tags in the same order and no tag in the set is the same as any other tag in the set.

25. The method of claim 24, wherein associating a tag comprises:
removing the tag from the buffer.

26. The method of claim 25, further comprising:
returning the tag to the first tag generator after associating the return portion with the retain portion.

27. The method of claim 26, further comprising:
returning the second tag to the second tag generator after sending the return portion.

28. The method of claim 22, wherein the sender and target are different layers of a multi-layer switch coupling a processor to a memory, the forward item includes a memory transaction, and the reverse item includes a result of the memory transaction.

29. The method of claim 28, wherein the processor is a graphics processor.

30. The method of claim 22, wherein the sender is a processor and the target is a layer in a multiple-layer switch having a plurality of layers.

31. The method of claim 30, wherein the processor is a graphics processor.

32. The method of claim 23, wherein each of the first and second tag generators is a counter and initializing comprises:

setting both counters to the same value.

33. The method of claim 32, wherein associating a tag comprises:

incrementing the counter; and

associating the value output by the counter with the tag.

34. The method of claim 32, wherein the counters are incremented continuously according to a clock signal and associating a tag comprises:

associating the value output by the counter with the tag.

35. A method comprising:

identifying a forward item including a transmit portion and a retain portion;

associating a tag with the retain portion;

sending the transmit portion, but not the tag, to a target that identifies a return portion corresponding to the transmit portion, independently generates the tag, and associates the tag with the return portion;

receiving the return portion and the tag from the target;

identifying the retain portion using the tag; and

associating the return portion with the retain portion to create a reverse item.

36. A method comprising:

receiving a transmit portion of an item from a sender that associates a tag with a retain portion of the item and sends the transmit portion, but not the tag;

identifying a return portion corresponding to the transmit portion;

independently generating the tag;

associating the tag with the return portion;

sending the return portion and the tag to the sender, wherein the sender identifies the retain portion using the tag and associates the return portion with the retain portion to create a reverse item.

37. A method for use in a switch having a plurality of input elements, each coupled to an internal switch bus, and a plurality of output elements, each coupled to the internal switch bus, and each coupled to a different destination external to the switch,

comprising:

at an input element,

receiving a first item sent from a source, the first item including an address portion specifying one of the output elements, and

sending the first item and an internal switch address of the input element to the output element specified by the address portion; and

at the output element,

removing from the first item the portion of the address specifying the output element,

generating a tag uniquely identifying the first item to the output element,

associating the tag and the internal switch address of the input element,

sending the first item, but not the tag or the portion of the address specifying the output element, to the destination coupled to the output element, wherein the destination independently generates the tag and identifies a second item corresponding to the first item,

receiving the second item and the tag from the destination,

identifying the internal switch address of the input element using the tag, and

sending the second item to the input element using the internal switch address of the input element.

38. A method comprising:

receiving, at a switch, an item sent from a source, the item associated with a first tag identifying the item uniquely to the source;

associating a second tag with the first tag, the second tag identifying the item uniquely to the switch; and

sending the item, but not the second tag, to a destination.

39. The method of claim 38, further comprising:

receiving a second item and the second tag from the destination;
identifying the first tag using the second tag; and
sending the second item and the first tag to the source.

5 40. The method of claim 38, wherein the destination is a second switch, further comprising, at the second switch:
independently generating the second tag;
associating a third tag with the second tag, the third tag identifying the item uniquely
to the second switch; and
10 sending the item, but not the third tag, to a second destination.

41. The method of claim 40, further comprising, at the second switch:
receiving a second item and the third tag from the second destination;
identifying the second tag using the third tag; and
15 sending the second item and the second tag to the switch.

42. The method of claim 41, further comprising, at the switch:
receiving the second item and the second tag from the second switch;
identifying the first tag using the second tag; and
20 sending the second item and the first tag to the source.

43. A computer program product, tangibly stored on a computer-readable
medium, comprising instructions operable to cause a programmable processor to:
at a sender,
25 identify a forward item including a transmit portion and a retain portion;
generate a tag;
associate the tag with the retain portion;
send the transmit portion, but not the tag, to a target;
at the target,
30 receive the transmit portion;
identify a return portion corresponding to the transmit portion;

independently generate the tag;
associate the tag with the return portion;
send the return portion and the tag to the sender;
at the sender;
5 receive the return portion and the tag;
identify the retain portion using the tag; and
associate the return portion with the retain portion to create a reverse item.

10 44. The computer program product of claim 43, wherein the tag is independently generated by a first tag generator at the sender and by a second tag generator at the target, further comprising instructions operable to cause a programmable processor to:
initialize the first and second tag generators to generate the same tags in the same order.

15 45. The computer program product of claim 44, wherein each of the first and second tag generators is a buffer and instructions operable to cause a programmable processor to initialize comprise instructions operable to cause a programmable processor to:
load each buffer with a set of tags such that both buffers contain the same tags in the same order and no tag in the set is the same as any other tag in the set.

20 46. The computer program product of claim 45, wherein instructions operable to cause a programmable processor to associate a tag comprise instructions operable to cause a programmable processor to:
remove the tag from the buffer.

25 47. The computer program product of claim 46, further comprising instructions operable to cause a programmable processor to:
return the tag to the first tag generator after associate the return portion with the retain portion.

48. The computer program product of claim 47, further comprising instructions operable to cause a programmable processor to:

return the second tag to the second tag generator after send the return portion.

49. The computer program product of claim 43, wherein the sender and target are different layers of a multi-layer switch coupling a processor to a memory, the forward item includes a memory transaction, and the reverse item includes a result of the memory transaction.

50. The computer program product of claim 49, wherein the processor is a graphics processor.

51. The computer program product of claim 43, wherein the sender is a processor and the target is a layer in a multiple-layer switch having a plurality of layers.

52. The computer program product of claim 51, wherein the processor is a graphics processor.

53. The computer program product of claim 44, wherein each of the first and second tag generators is a counter and instructions operable to cause a programmable processor to initialize comprise instructions operable to cause a programmable processor to: set both counters to the same value.

54. The computer program product of claim 53, wherein instructions operable to cause a programmable processor to associate a tag comprise instructions operable to cause a programmable processor to:

increment the counter; and

associate the value output by the counter with the tag.

55. The computer program product of claim 53, wherein the counters are incremented continuously according to a clock signal and instructions operable to cause a

programmable processor to associate a tag comprise instructions operable to cause a programmable processor to:

associate the value output by the counter with the tag.

5 56. A computer program product, tangibly stored on a computer-readable medium, comprising instructions operable to cause a programmable processor to:

 identify a forward item including a transmit portion and a retain portion;

 associate a tag with the retain portion;

 send the transmit portion, but not the tag, to a target that identifies a return portion

10 corresponding to the transmit portion, independently generates the tag, and associates the tag with the return portion;

 receive the return portion and the tag from the target;

 identify the retain portion using the tag; and

 associate the return portion with the retain portion to create a reverse item.

15 57. A computer program product, tangibly stored on a computer-readable medium, comprising instructions operable to cause a programmable processor to:

 receive a transmit portion of an item from a sender that associates a tag with a retain portion of the item and sends the transmit portion, but not the tag;

20 identify a return portion corresponding to the transmit portion;

 independently generate the tag;

 associate the tag with the return portion;

 send the return portion and the tag to the sender, wherein the sender identifies the retain portion using the tag and associates the return portion with the retain portion to create a

25 reverse item.

30 58. A computer program product, tangibly stored on a computer-readable medium, for use in a switch having a plurality of input elements, each coupled to an internal switch bus, and a plurality of output elements, each coupled to the internal switch bus, and each coupled to a different destination external to the switch, comprising instructions operable to cause a programmable processor to:

at an input element,

receive a first item sent from a source, the first item including an address portion specifying one of the output elements, and

send the first item and an internal switch address of the input element to the output element specified by the address portion; and
at the output element,

remove from the first item the portion of the address specifying the output element,

generate a tag uniquely identifying the first item to the output element,

associate the tag and the internal switch address of the input element,

send the first item, but not the tag or the portion of the address specifying the output element, to the destination coupled to the output element, wherein the destination independently generates the tag and identifies a second item corresponding to the first item,

receive the second item and the tag from the destination,

identify the internal switch address of the input element using the tag, and

send the second item to the input element using the internal switch address of the input element.

59. A computer program product, tangibly stored on a computer-readable medium, comprising instructions operable to cause a programmable processor to:

receive, at a switch, an item sent from a source, the item associated with a first tag identifying the item uniquely to the source;

associate a second tag with the first tag, the second tag identifying the item uniquely to the switch; and

send the item, but not the second tag, to a destination.

60. The computer program product of claim 59, further comprising:

receive a second item and the second tag from the destination;

identify the first tag using the second tag; and

send the second item and the first tag to the source.

61. The computer program product of claim 59, wherein the destination is a second switch, further comprising, at the second switch:

independently generate the second tag;

associate a third tag with the second tag, the third tag identifying the item uniquely to the second switch; and

send the item, but not the third tag, to a second destination.

62. The computer program product of claim 61, further comprising, at the second switch:

receive a second item and the third tag from the second destination;

identify the second tag using the third tag; and

send the second item and the second tag to the switch.

63. The computer program product of claim 62, further comprising, at the switch:

receive the second item and the second tag from the second switch;

identify the first tag using the second tag; and

send the second item and the first tag to the source.